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NPIC 6/68 Copy #2 [redacted] File 02228

[redacted]

December 7, 1967

U. S. Government

Attn: Mr. Bill K.

Gentlemen:

The [redacted] has reviewed your request RD 10-68 for a Twin Stage On-Line PI Comparator (#02228) and is most pleased to be responsive. We offer the attached proposal which describes our approach to the development of an instrument which will provide the Photo Interpreter with the added capability of obtaining precision measurements. It is both theoretically feasible and practical. Consideration will be given to obtaining the greatest possible flexibility and usefulness.

QUALIFICATIONS OF THE [redacted]

We believe ourselves to be exceptionally well qualified to undertake this program for your Agency. Our capability and responsiveness to expressed needs are well demonstrated first by the instruments already in your facilities and second, by those instruments provided to other Government Agencies, universities, and industry.

These accomplishments include the design and manufacture of complete systems with digital readout or preprogramming to meet special user needs. Of note, are the [redacted] Type 1032 Microdensitometer with digital readout on magnetic tape for reconnaissance and re-entry photography data reduction; the [redacted] Type 1205 Semiautomatic Stellar Comparator, originally developed for satellite geodesy and since modified for terrain as well; the [redacted] Type 1480 Photorepeater for production of photomasks with very high resolution and large format geometries and a positional precision of 10 microinches or better; the [redacted] Type 1600 Pattern Generator for the manufacture of reticles to be

[redacted]

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used in the Photorepeater to generate the photomasks; the [ ] Type 1222 Photoelectric Line Setting Instrument for reducing positional and density data from X-ray diffraction or spectrographic films or plates; and the [ ] Type 1300 On Line Interferogram Reader for analysis of supersonic and hypersonic windtunnel data. Most of these systems are now standard products of the [ ]

STAT STAT STAT

Because of our experience, knowledge and capabilities in the design and manufacture of opto-electro-mechanical systems for precise photographic data reduction and creation we are confident that we can successfully accomplish the objectives of the program described in the attached proposal.

SPECIAL CONSIDERATIONS

You will note that this proposal includes provision for a Measurement Read-out System other than the [ ] system mentioned in your request. We propose a modern readout system composed of solid state components and integrated circuits for the purposes of compactness, data handling capacity, reduced heat dissipation requirements, accessibility for service, and high degree of reliability. The requirements for the proposed data acquisition system are well within the state-of-the-art and no unusual difficulty is seen in meeting all these requirements. While this would mean increased cost for the first unit, we expect the total cost of the first unit plus the larger quantity lots would be less expensive to the Government than those quantity prices quoted to us by the [ ] Furthermore, we believe the needs of the Government are best served by one contractor having system responsibility to the greatest extent possible as we have proposed. The [ ] a local company and subcontractor in this proposed effort, possesses excellent conceptual, design and manufacturing capabilities in the field of electronics. The high degree of reliability under long term continuous usage of systems manufactured [ ] for us over the last seven years cannot be overemphasized. It lends considerable support to the inclusion of [ ] in this program. Their contribution is expected to effectively augment our efforts.

STAT STAT STAT STAT STAT

DEVELOPMENT AND PRODUCTION COSTS

We are pleased to provide a quotation for the development, manufacture, delivery, and installation of the [ ] Twin Stage On-Line PI

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STAT Comparator of [ ] fob Washington, D. C. area. This price includes
STAT an amount of [ ] for Items 1 and 2, page 2 of the contract pricing
sheets to be purchased from the [ ] Our terms STAT
are Net 30 days. Delivery is contingent upon timely receipt of vendor
STAT items. For example, [ ] quotes a delivery of 210 days
for the Stereo-viewer. On this basis, our expected delivery is 270 to
300 days delivery after receipt of order. Delivery within this period
will require extra effort on our part in view of the long delivery schedule
STAT quoted by [ ] This quotation is firm for a period of 60
days.

We are pleased to provide an estimate of production costs to you of the instrument in quantities of 5, 10, 15, and 20 as follows:

a lot of 5 instruments
a lot of 10 instruments
a lot of 15 instruments
a lot of 20 instruments [ ] STAT

These estimates are based on experience gained in the manufacture of
STAT standard [ ] instruments in one-of-a-kind and small multiple lots.
This information is intended for budgetary purposes only and should not
be construed as a firm quotation. Any quotation by the [ ] STAT
STAT [ ] shall be based on material, supplies, and vendor costs, as
well as labor, overhead, and G&A rates at the time of quotation.

CONTRACTUAL CONSIDERATIONS

STAT The [ ] intends to comply with Specification No. DB-1001 of 31 August 1966 (Attachment 1) relating to contract documentation; and with Attachment 2, Specification No. DB-1003 of the same date relating to preparation of technical manuals.

INTEREST

STAT The [ ] believes that the addition of the Twin Stage PI Comparator to your facilities will considerably augment your capabilities. We have studied and reviewed the requirements with real interest and wish to provide this instrument for your Agency in a timely fashion and to your complete satisfaction.

Sincerely yours, STAT

[ ]

Director of Marketing

ACT/mw
Enclosures

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TWIN STAGE ON-LINE PI COMPARATOR

This proposal, furnished in response RD 10-68, shall not be disclosed outside the Government or be duplicated used or disclosed, in whole or in part, for any purposes other than to evaluate the proposal, provided, that if a contract is awarded to the offeror as a result of or in connection with the submission of this proposal, the Government shall have the right to duplicate, use, or disclose this proposal to the extent provided in the contract. This restriction does not limit the Government's right to use information contained in this proposal if it is obtained from another source.

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SUMMARY

STAT The [redacted] is pleased to respond to your request RD 10-68 for a Twin Stage, On-Line, PI Comparator (#02228). We believe it is both theoretically feasible and practical to fabricate an instrument as described in this proposal. The instrument that we propose shall consist of a high performance stereo-viewing system; two independent scanning stages, one of which is digitized for measuring in two axes, and a measurement read-out system.

The viewing system shall be the [redacted] Stereo-viewer modified STAT to permit increased separation of the two turret optical center lines to approximately 18 in. This modification, in addition to the advantages mentioned in this proposal, forms the basis for a true stereo instrument. We believe that use of the unmodified [redacted] Stereo-viewer would STAT severely limit both present and future potential performance.

The scanning stages are to be designed and manufactured by proven techniques employed by the [redacted] as a general practice STAT for its high precision comparators. The range for both independent and common drive speeds shall be between 5 microns/sec and 5 mm/sec (1/1000 ratio) with a design goal for maximum speed of 0.5 in./sec. This maximum speed is selected on the basis that the desire for very high speeds coupled with the real need to maintain precise control at the minimum speed introduces unwarranted complexity and expense. Additionally, the requested positional accuracy of 1 part in 5000 shall be met or exceeded.

The requirements for the proposed Data Acquisition System are well within the state of the art, and no unusual difficulty is seen in meeting all of the requirements. All of the techniques contemplated for use in the system have been fully tested and proven both by us and by others. We have designed and built a number of similar systems of equal or greater complexity. All of these systems have performed as intended and are in current use. It is recognized, however, that the proposed system is fairly complex and will require taking considerable care at all stages of design to insure a completely satisfactory result. Integrated circuits on plug-in cards will be used for performing nearly all functions. In those cases where integrated circuits are not suitable for use because of their limited power handling ability, semiconductor circuits using discrete components will be used. The TTL type circuit logic planned for this system affords a high degree of immunity to noise, high speed, and excellent reliability.

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It has been pointed out in the Request for Quotation that the Data Acquisition System has been completely designed. However, we believe the needs of the customer are best served by one contractor having system responsibility to the greatest extend possible with the minimum possible divided responsibility. For this reason, we propose a modern digital measurement read-out system composed of solid state and integrated circuit components. While this would mean increased cost for the first unit, we expect subsequent units would be less expensive than those quantity prices quoted to us by

STAT [redacted]

STAT [redacted] believes itself exceptionally well qualified to undertake this program for your Agency. Our capability is well demonstrated by the performance of instruments already in your facilities. We intend to provide you with a new instrument which will more than adequately meet your operational objectives.

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STAT [redacted] DESIGN FOR TWIN STAGE,
ON-LINE PI COMPARATOR

INTRODUCTION

A need exists for the development of an operational prototype Twin Stage On-Line PI Comparator. This need is based on the desire of the Photo Interpreter to measure small distances on film that has been cut out of exposures of interest. These and duplicate cut-outs (film chips) can be placed on the twin stage comparator and identification made with stereo aid of the desired point of measurement. Measurements then can be made without transfer of film chips to another instrument. Prior to the development of the twin stage comparator, the Photo Interpreter has simply identified the desired point of measurement and measurements were made by a separate group with higher precision comparators. Our understanding is that in the design of this instrument emphasis is to be placed on ease of operation, reliability, simplicity, measuring accuracy and reasonableness of price for production quantities of 10 or more. [redacted] STAT

STAT [redacted] proposes to provide your laboratory with an instrument based on the design objectives outlined in your request which will more than adequately meet your operational objectives.

This shall be a compact stereo chip comparator incorporating a high performance stereo-viewing system, two independent scanning stages, one of which is digitized for measurement in two axes, and a measurement read-out system.

The two scanning stages shall have free aperture of 6 in. x 6 in. and full 6 in. x 6 in. (±3 in.) travel without interference. Design will include differential drive to accommodate measurements on chips of different scales.

The viewing system shall consist of the [redacted] High Power Stereo- STAT viewer described in Attachment 3 of your request, modified to permit independent travel of both stages without interference and fine focus adjustment. The measurement read-out system shall be designed to be compatible with the customer in-house computer on-line operation requirements as detailed in Attachment 5.

DETAILED DESCRIPTION

Viewing System

In order to permit full 6 in. x 6 in. travel of both stages and still retain

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mechanical stability, we believe the separation of the optical center lines of the two turrets on the stereo-viewing system must be greater than the presently available 12 in. of the [redacted] system described in Attachment 3. Therefore, we propose to use that system and to modify it to permit increased separation of the optical center lines of the viewing turrets without deterioration of the present optical performance. This modification is to be accomplished by changing the realy design. The intended changes will allow (a) Approximate .18 in. separation of the viewing turrets, (b) a fine focus adjustment, (c) the use of the instrument over a larger scale differential, and (d) relaxation of the chip cut-out requirements.

STAT [redacted] has considerable expertise in the extensive
STAT modification of [redacted] Dynazoom pods. We are using these pods in conjunction with relay systems of our own design as demonstrated in the 80 power magnification system of the [redacted] Type 880 and 1210 comparators in use at the customer facility. Our modifications include changes from an angle to a straight line viewing system, replacement of objectives, and addition of 1:1 relay systems. We have made necessary changes to the zoom feature and have centered objectives to permit magnification power changes without image shift.

There is a requirement for a reticle in each of the optical trains. Our understanding is that the reticle in the scan (non-measuring) stage optical train is intended for use only in optical alignment of the film chips. For it to remain in the system during actual measuring would produce eyestrain. Consequently, our design shall include a means for removal of this reticle from the optical path during the measuring mode of operation.

STAT After a review of the [redacted] Stereo-viewer which include the use
STAT of [redacted] objectives, a check was made of comparative performance of these and other objectives available in our laboratory. Tests and prior
STAT experience indicate that the [redacted] objective's characteristics include a flatter resolution field than the comparable [redacted] objectives.

It is our intention to try these objectives in a system at an early date during the contract to demonstrate expected system performance improvement. If improvement is apparent, we plan to request a contract amendment to
STAT substitute the [redacted] objectives for those specified in Attachment 3.

This further benefit afforded by the new relay design is the ability to have

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independent fine focus adjustment for each leg of the system. This is a highly desirable capability which is not present in the [redacted] STAT system.

Film Stage and Hold-down System

There shall be two film stages, each capable of handling film chips in sizes up to 6 in. x 6 in.

Each of the film stages shall be supported on separate X-Y carriage assemblies.

Each of the X-Y carriage assemblies shall have independent translation of ±3 in. in both of the X axis and the Y axis. The carriage assemblies shall be mounted on a common Meehanite base. Each shall be supported by selected high precision ball bearings, and shall be guided using low-friction guide shoes spring-loaded against lapped guiding keys. This is proven technique employed on other [redacted] precision instruments. The measuring stage construction shall permit a mechanical rotation of ±10° of its film support surface about the center of the clear aperture. The non-measuring stage construction shall permit a rotation of 360° of its film support surface about the center of the clear aperture.

STAT

A feature requested is a variable differential drive between the two film stages to permit the scanning of two images of different scale in stereo, with the motions remotely controlled at the operator's console. Additionally, provision is requested for both independent and common drive speeds to range between 0.0002 in./sec and 1 in./sec.

Experience dictates that as the system response to change approaches true linearity, differential performance becomes more satisfactory and is useful over a larger range of differential travel. We believe that any attempt to operate in a range between 0.0002 in./sec and 1 in./sec would introduce non-linearities and degrade synchronism of the differential stage motions to a point of questionable usefulness.

Furthermore, experimental and analytical examination of the interrelationship between the required accuracy, desired magnification, and speed and control of approach to setting target establishes the need for a maximum slow-speed setting capability of 0.0002 in./sec. This, to some extent, determines the screw pitch and the maximum allowable speed rate.

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We propose lead screws of 5 mm lead per revolution to provide for transportation of the stages at 5 microns/sec, minimum speed and 5 mm/sec (1 revolution), maximum speed with a design goal of 0.5 in./sec for the maximum speed. If feasible, this limit shall become a part of the instrument performance specification. Since the distance between most points of interest on a film chip are small and can be traversed in a short time, the desire to obtain very high speeds coupled with the need to maintain precise control at the minimum speed introduces considerable and unwarranted expense. The gains achieved would be offset by the necessity for complex servos, as well as extra lubrication and cooling of the screws, and the introduction of operational problems. For example, the combination of a translation rate as high as 1 in./sec and the small field of view permitted by the optics are basically incompatible.

We propose to use four independent motors - one on each screw, with a single joystick control for all motors. Control shall be accomplished (remotely) with the console election of push button options, LEFT, RIGHT, BOTH for stage translation, and panel selection of variable differential drive over a five fold range (1:1 to 5:1) between the measuring stage and the non-measuring stage. STAT

The motors shall be of the velocity servo type commonly used at the [redacted] STAT on our fully automated Photorepeaters. Our experience indicates that these motors should be adequate for the task at hand. It is understood that precise speed ratios with the attendent elaborate drives are not required.

The film hold-down shall be accomplished using the manual upper film pressure plate such that at 200 power magnification the film shall remain flat and in sharp focus over a minimum area of 1 in. square. At lower powers, the film shall remain in sharp focus over the entire format.

Film Measurement System

One of the two film stages shall have a measuring capability. This measuring stage shall have two axis (X and Y) digitizers with a measuring range of ±3 in. in both axes.

STAT Two [redacted] Type H1045 encoder heads shall be geared thru backlash compensation devices to the X and Y axis lead screws of the measuring stage. The backlash compensation system shall permit the measurement to be taken in either direction of motion of the respective stage. This technique

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has been successfully employed by the [redacted] in its Type 1032 Digital Microdensitometer and in the Type 1205 Automatic Comparator. The accuracy of measurement shall be ±2 microns for measurement of 1 in. or under. The requested accuracy of 1 part in 5000 over the entire film format shall be met or exceeded. Standard design of the [redacted] systems includes the specification of accuracy of 1 part in 100,000. The orthogonality of the X and Y axes shall be within 5 sec of arc. The objective of maintaining the highest possible accuracy over short distances may well be accomplished with the incorporation of standard [redacted] practices used in the manufacture of high precision comparators.

STAT STAT STAT

Measurement Read-out System

It is understood that the stereo comparator will have two film stages, which will be moved by two sets of X and Y lead screws. The lead screws will be driven by four velocity servos under the control of a joystick. The system will be arranged to allow moving the stages separately, together, or with one stage moving at a speed which is proportional to the speed of the other.

When the operator has made a setting on an image, he will command a position reading to be made. The digital values of the X and Y coordinates of one of the film stages will be automatically read, and these values along with other data inserted by the operator will be transmitted to a remote computer. The data system will then wait for an acknowledgment or error signal from the computer, and if necessary, the data will be automatically transmitted again.

The digital coordinate values will be derived from two optical encoders, one of which will be connected through gears to each of the X and Y lead screws of the measuring stage. The encoders will be driven by the gears at five times the speed of the screws. Each of the encoders will generate two voltages which will vary in a roughly sinusoidal manner as the encoder turns. Each voltage will complete 500 cycles per turn of the encoder, and the two voltages will be in phase quadrature. One of these voltages will be fed to a pulse-forming circuit in the data acquisition system, which circuit will produce 1000 pulses for each turn of the encoder. The other encoder output voltage will be used to determine the sense of encoder rotation. This arrangement will provide one pulse for each micron of stage motion.

The pulses from each encoder will be fed to a reversible counter. By adding or subtracting a count for each micron of stage motion, the counters will accumulate values which will provide a continuous indication of the X

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and Y coordinates of stage position. Provision will be made for resetting the counters to zero and for setting them to preset values selected by the operator. A switch for each counter will be provided for reversing the sense of counting. The coordinate values will be displayed to the operator on two Nixie tube displays. Each display will consist of six decimal digits plus sign.

The digital displays and all operator controls for the data acquisition system will be mounted on a control panel in an arrangement identical to that of the [redacted] Control Panel, model 2825A. The controls, data format and sequence of operations required of the system are completely described in the specifications. This description will not be repeated here in detail, but all of the controls and features described in the specification will be provided, and the system will be designed to perform the sequence of operations exactly as described therein.

On command, the data acquisition system will generate a signal in the specified format, and this signal will be fed through a cable to a remote computer. A signal generated by the computer acknowledging receipt of the message will be received by the system on another cable. It is understood that the cables and the connections to the computer are to be provided by the customer. It is also understood that the computer is located in the same building and the cable is not so long as to require compensating networks or special signal restoring amplifiers. Services for programming and operating the computer as required to check out and operate the system are to be provided by the customer.

The control panel, counters, signal processing circuits, power supplies, etc. will be mounted in a single cabinet. Integrated circuits on plug-in cards will be used for performing nearly all functions. In those cases where integrated circuits are not suitable for use because of their limited power handling ability, semiconductor circuits using discrete components will be used.

The Type of integrated circuit logic used will be TTL. Integrated circuits of this type, properly used, afford a high degree of immunity to noise, high speed, and excellent reliability. The availability of complex functions in a single TTL package reduces the number of interconnections and thereby further enhances reliability. Their small size allows placing much more logic on each card, reducing the number of cards required and further reducing the number of interconnections. The lower power requirements of integrated circuits as compared to discrete component circuits allows

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the use of smaller power supplies and effectively eliminates heat dissipation problems in most of the circuits.

Since fewer cards and less power are required by integrated circuits, it is feasible to design a more compact unit without sacrificing accessibility for service. It is understood that compact size, while preserving ready accessibility, is a required feature of the system.

Through careful circuit design and the use of large electrical margins, the counters and signal processing circuits will be made immune to outside interference and free of extraneous pulses. The counters will maintain a precise indication of stage position for indefinite periods of time. A high degree of reliability will be a prime design consideration.

The requirements for the proposed data acquisition system are well within the state of the art, and no unusual difficulty is seen in meeting all of the requirements. All of the techniques contemplated for use in the system have been fully tested and proven both by us and by others. We have designed and built a number of similar systems of equal or greater complexity. All of these systems have performed as intended and are in current use. It is recognized, however, that the proposed system is fairly complex and will require taking considerable care at all stages of design to insure a completely satisfactory result.

Stage Illumination

The stage illumination system is designed to meet the requirements of Section 4.5 of your request.

The film shall be supported on special glass platens inlet into the upper surfaces of the rotary and pivot tables. The upper surface of these 1/4 in. thick support platens shall be opalized to give maximum light for the high Numerical Aperture objectives used. Conventional Abbe' microscope illumination systems cannot be brought close enough to the film plane because of the glass pressure plates needed to hold the film flat. The manually operated pressure plates shall be hinged and pivoted at the rear to permit convenient operation. The microscope illumination shall be two independently controlled tungsten iodide lamps whose spectral output is filtered to remove the non-visible radiant (1 R) light. These light sources shall be remotely located in the bottom rear of the support console in such a manner and position that thermal heating is minimized and fan cooling may

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be eliminated. Air will, however, be directed across the upper film pressure platen and objective lens into to provide adequate film cooling. The general field of measurement shall be illuminated by fluorescent lamps located on the X axis stages and controlled by a switch on the instrument console.

The Control Console

The complete system shall be designed in accordance with correct ergonomic principles for easy, comfortable, rapid operation.

Electrical controls shall be provided for setting a 5 to 1 variable differential drive between the corresponding axes of the stages.

Continuously variable speed drive controls shall cover the range of 5 microns/sec to 5 mm/sec with a design objective of 0.5 in./sec for maximum speed.

The joystick, stage translation selector push button, the variable differential selector, and independent controls for intensity variation shall all be located conveniently at the front of the console on which the comparator is mounted. The measurement readout system including power supply display shall be located in a separate Emcor II rack. An artist's conception of these units is attached.

Overall Physical Consideration

The console shall be a rigid steel weldment providing support for the comparator section and its controls. The console shall meet the specified size requirements and shall be provided with suitable casters and leveling for portability and leveling. The leveling jacks shall terminate in vibration isolators to provide protection against local external vibrations.

The environment of a system is extremely important when precision of measurement is to be maintained. While the instrument is unaffected, we believe that the conditions specified in your Request for Proposal are not sufficient for maintenance of the precision stated elsewhere in your request. The following is a statement of practices recommended by the [redacted] STAT

STAT [redacted]

"Precise measurement is a function of not only the instrument involved and its operator but also of the environment in which both perform.

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The room should be large enough to permit free access and operation of the instrument and be relatively free of contaminants such as dust.

For extremely precise work a "clean room" or "clean bench" is recommended. These units should not only supply a clean, filtered air flow over the instrumentation but also provide a control of temperature and relative humidity as well. The air flow rate should not exceed 3 to 4 miles per hour velocity and not be subject to sudden temperature shears.

Temperature should be regulated to ±1°F and be known. For work with film or emulsion coated materials, a relative humidity of 50% ±5% is suggested."

Shielding shall be provided throughout the system so that no critical circuits are RFI.

Reliability and Service Time

The comparator and related equipment shall be designed to withstand service usage, under normal operating conditions, for a period of 500 hours (5 hours per day operation) without significant degradation of performance, and with only minor maintenance due to normal expendable replacement parts.

The design shall permit: (1) ease of assembly and disassembly, (2) ready access to potential trouble sources, (3) maintenance with tools and equipment normally available to maintenance personnel, and (4) external test points.

Miscellaneous

STAT The [redacted] shall provide the following: (1) Operators Instruction Manual, (2) Maintenance Manual (including schematics), (3) Recommended spare parts list, including the cost of each item and the total parts package cost. (Per specification DB-1003, dated August 31, 1966).

All necessary alarms, warning lights, and safety features shall be included to permit the most reliable and safe operation of the instrument possible. All controls shall be conveniently located and readily accessible.

Reporting

STAT The [redacted] agrees to comply with reporting procedures

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as stated in specification DB-1003.

CONCLUSION

As indicated in our introduction, the need for the above described Twin Stage On-Line Comparator appears to be of sufficient importance that every effort should be made to give consideration to the most flexible and useful design possible. We believe it is both theoretically feasible and practical to fabricate the instrument described in our proposal. Each of the problems anticipated in the manufacture of the instrument have been described in the section of concern.

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January 16, 1968

U. S. Government

Attn: Mr. Bill K.

Gentlemen:

In response to your Bill Mc T., we are pleased to provide the following quotation as an amendment to our proposal furnished in response to RD-10-68.

Item #1 Digitization of second stage of the Twin Stage On-Line PI Comparator including adaptation for data heads, data heads, and necessary measurement readout display $8,693

Delivery of the above would be concurrent with the original proposal, and this quotation is firm for a period of 60 days. Our terms are Net 30 days, and all prices are fob [redacted] This quotation is for a single comparator. STAT

We trust that this information is sufficient for your further consideration of our proposed instrument.

Sincerely yours,

STAT [redacted]

Director of Marketing

ACT/mw

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